



Iron Enrichment of Sea Water

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Iron Enrichment of Sea Water

- A study on the possible environmental consequences of artificially increasing iron in off-shore Hawaiian waters.
- http://www.hawaiipictures.com/pictures/maui_4.html





Background

- Kyoto Protocol
 - International agreement to reduce global warming by lowering carbon emissions.
 - All developed countries have ratified it except the US and Australia
 - India and China are exempt, however China emits more pollution than the US.
 - In order to follow the guidelines of the protocol, some countries buy shares in companies that reduce global warming, creating a stock market for carbon.



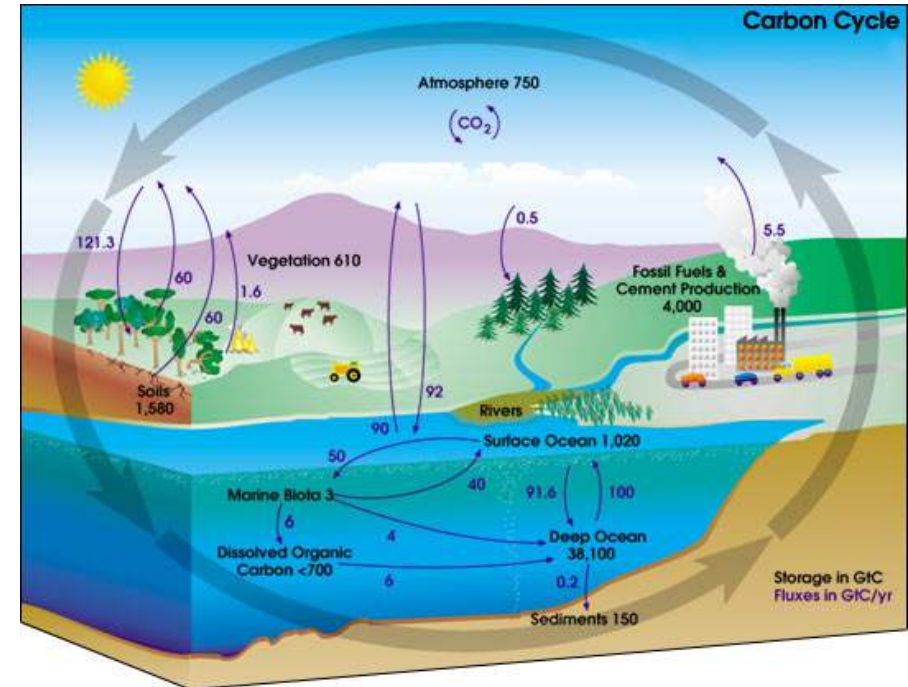
Background

- There are some companies that wish to be a part of this carbon economy by adding iron to parts of the ocean.
- Certain parts of the ocean are nutrient rich, but low in iron.
- Iron is the limiting nutrient in phytoplankton growth for these areas.
- By adding iron, the companies hope to increase phytoplankton growth.



Background

- Since phytoplankton photosynthesize, more phytoplankton leads to less carbon in the atmosphere.
- "The Carbon Cycle." NASA Earth Observatory. NASA. 28 Mar. 2007
<http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html>.





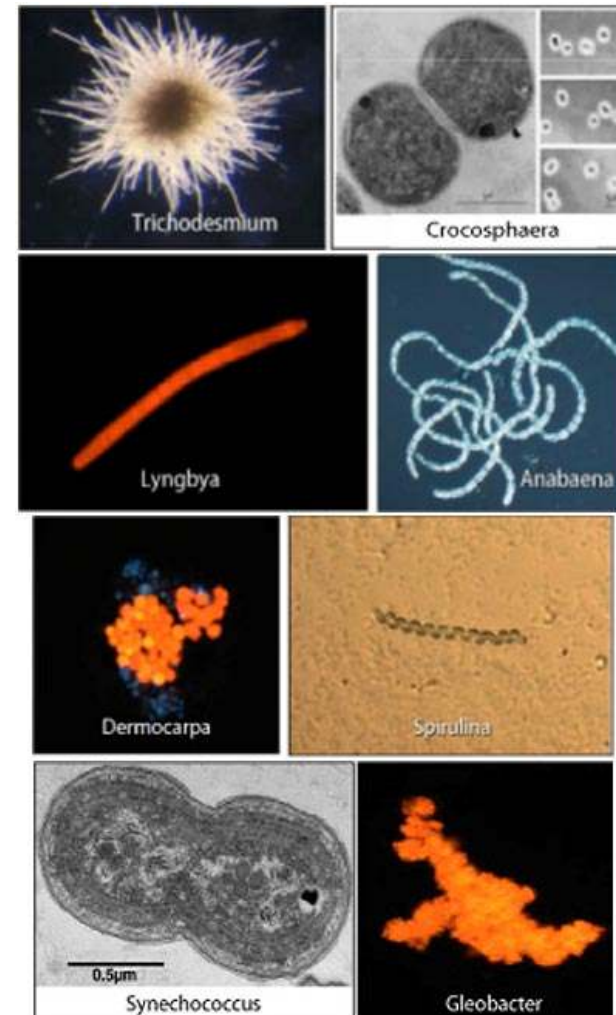
Background

- There are two main problems:
 - Carbon does not stay in the ecosystem for a long time.
 - Animals eventually decompose, returning most of the carbon to the atmosphere.
 - They want to add iron off of Hawaiian shores, which is not a prime location.
 - Hawaiian waters do not have enough nutrients to support phytoplankton.



Background

- Instead of growing phytoplankton, we could increase the cyanobacteria growth
 - Cyanobacteria growth is influenced by iron
- Cyanobacteria do not need as much nutrients as phytoplankton.
- While some species of Cyanobacteria are harmless, others contain toxins like neuro-, hepa-, cyto-, and endotoxins.
- <http://web.mit.edu/mit-who/ww/research/bo/figs/cyanobacteria.jpg>





Background

- Cyanobacteria have been shown to probably be the cause of a disease in the Chamorro Indians of Guam. This disease is similar to Alzheimer's or A.L.S.
 - Amyotrophic lateral sclerosis or Lou Gehrig's disease which is a motor neurone disease.
- <http://www.navycthistory.com/newnavypagejanjul2005.html>





Background

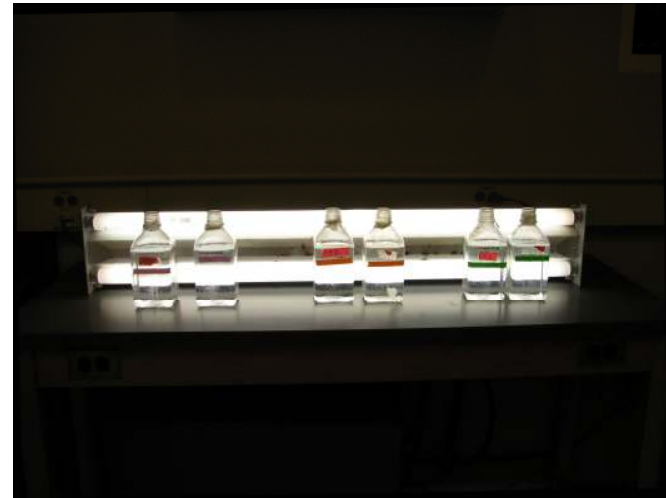
- Essentially:
 - If these companies add iron to the waters off of Hawaii, they could cause a bloom of cyanobacteria instead of phytoplankton, which could have medical consequences.
 - Stephen Hawking (right)
- <http://www.sfgate.com/blogs/images/sfgate/techchron/2006/09/07/hawking.jpg>





Setup

- Six Bottles of Seawater
 - Two Controls
 - Two at Low Concentration of Iron
 - Two at High Concentration of Iron





Setup



- Iron solution was added in differing quantities to achieve different concentrations.



Procedures

- Visual Observations
- Filtering
- Microscopy
 - Studying the samples using microscopes.
- Flow Cytometry
 - The counting of cells.





Procedures

- Visual Observations
 - Taken daily for all containers.
- Filtering, Microscopy, Flow Cytometry
 - Initially
 - Middle of Project
 - End of Project
- Experiment ran for a total of 18 days



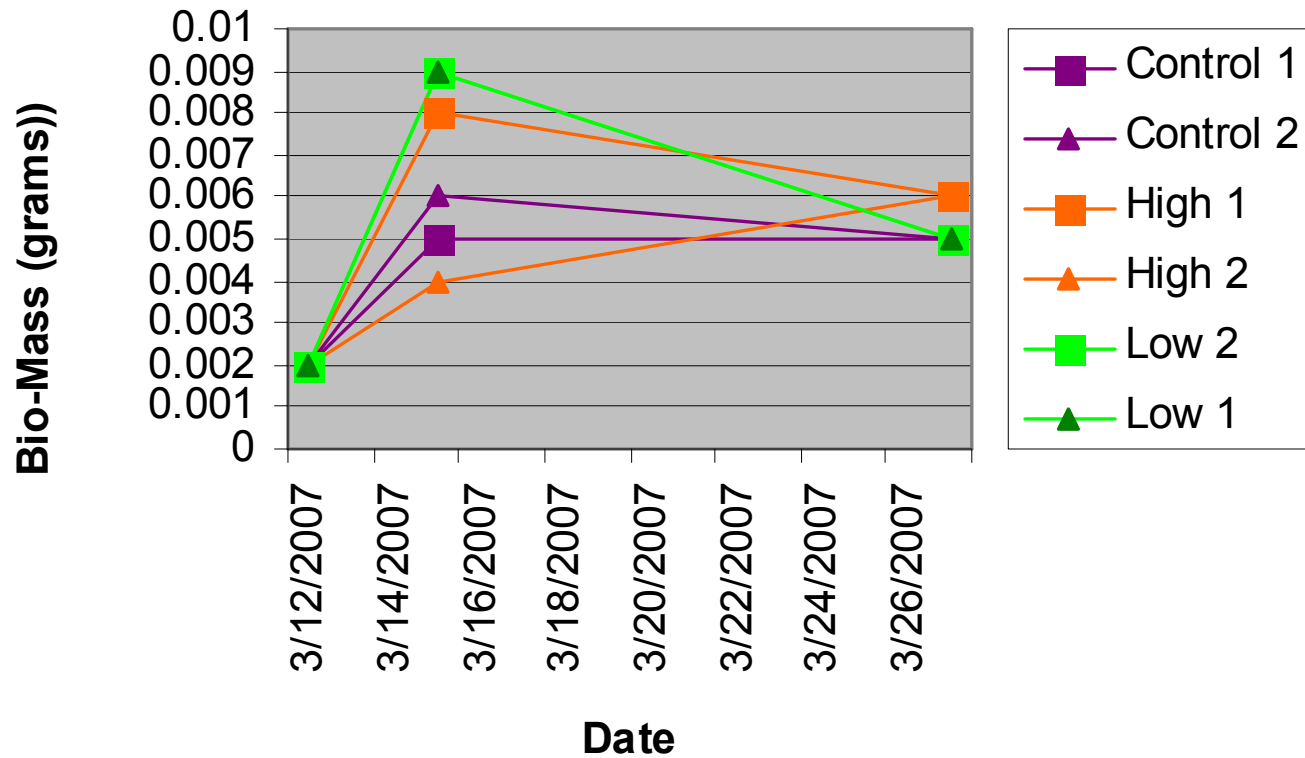
Filtering





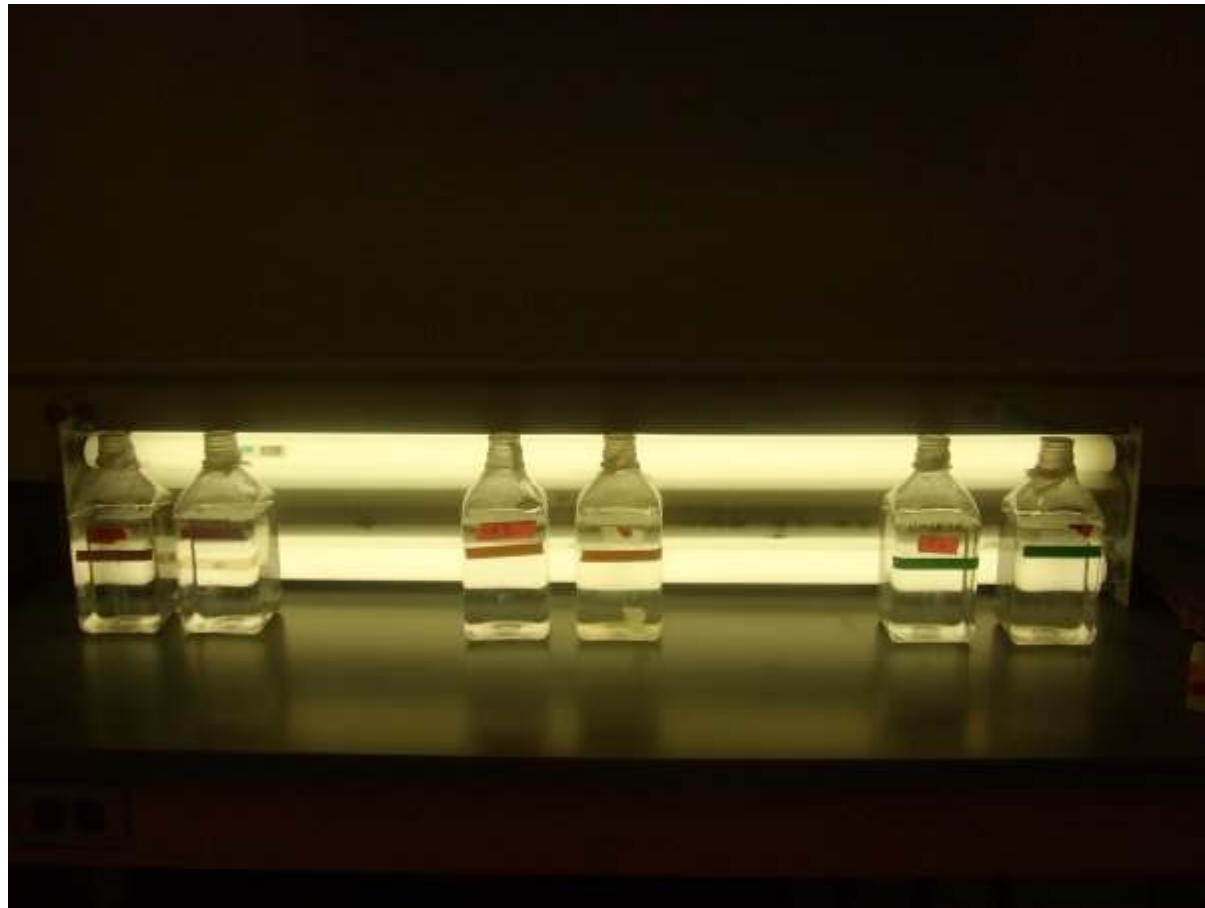
Results

Change in Bio-mass through Filtration





Visuals





Visuals

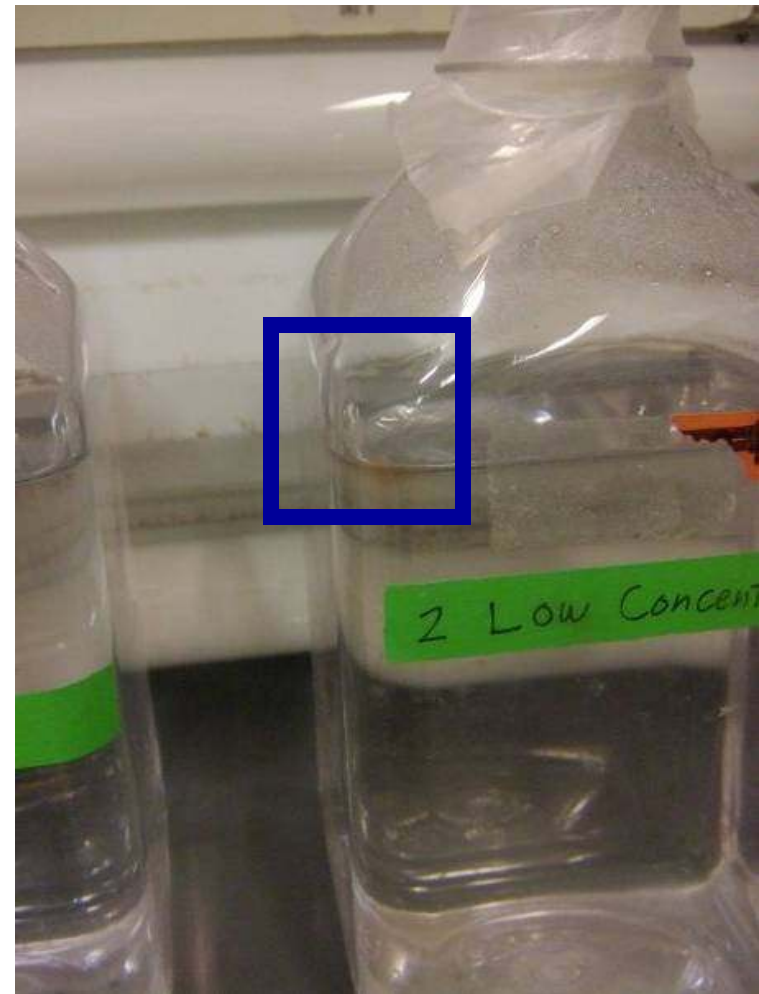
- No change was observed until after Spring Break.
- A very faint water line would be seen in the high concentration bottle.
- No change was observed in the controls.
- Brown growth was seen in both low concentration bottles.





Visuals

- Brown growth was seen in both low concentration bottles.



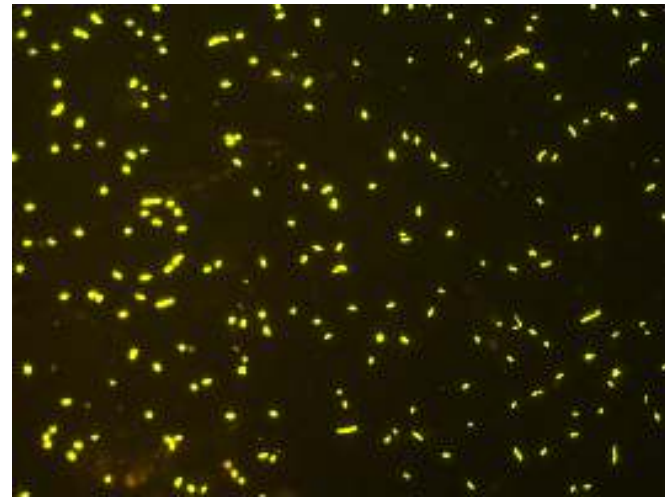
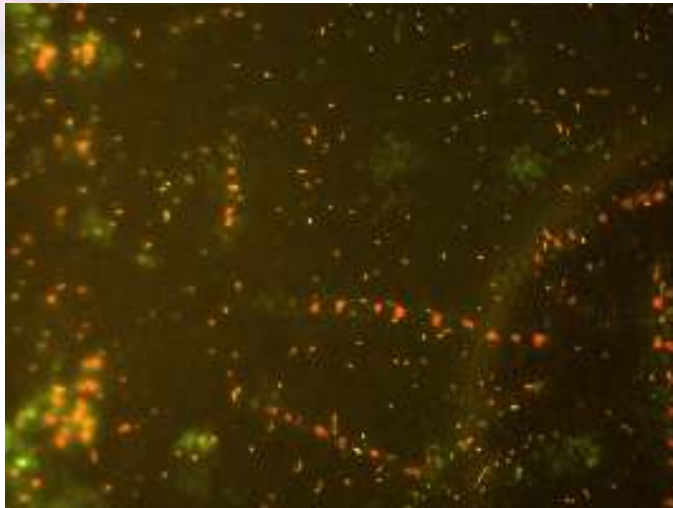


Initial Results for Microscopy





Initial Results for Microscopy



- High Concentration showed a bloom in *Synechococcus*, a type of Cyanobacteria and diatoms.
 - *Synechococcus* is generally harmless.



Initial Results for Microscopy

- Low Concentration showed a bloom in an unknown eukaryotic autotroph.
- Research is still being completed.
 - Results for the rest of the bottles and the flow cytometry work is pending.





Flow Cytometry





Acknowledgements

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- Mr. Marcus Kaya

